UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF NORTH CAROLINA
ASHEVILLE DIVISION

STATE OF NORTH CAROLINA ex rel. Roy Cooper, Attorney General,	)	
Plaintiff,	)	No. 1:06-CV-20
vs.	)	**VOLUME 9A**
TENNESSEE VALLEY AUTHORITY,	)	[Page 2085-2158]
Defendant.	)	

TRANSCRIPT OF TRIAL PROCEEDINGS
BEFORE THE HONORABLE LACY H. THORNBURG
UNITED STATES DISTRICT COURT JUDGE
JULY 24, 2008

APPEARANCES:

On Behalf of the Plaintiff:

JAMES C. GULICK, Senior Deputy Attorney General
MARC BERNSTEIN, Special Deputy Attorney General
North Carolina Department of Justice
114 West Edenton Street
Raleigh, North Carolina

MICHAEL D. GOODSTEIN, Esquire
ANNE E. LYNCH, Esquire
Resolution Law Group, P.C.
5335 Wisconsin Avenue NW, Suite 360
Washington, DC

On Behalf of the Defendant:

FRANK H. LANCASTER, Senior Attorney
HARRIET A. COOPER, Assistant General Counsel
THOMAS F. FINE, Assistant General Counsel
MARIA V. GILLEN, Assistant General Counsel
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee

I N D E X

DEFENSE WITNESSES: **PAGE**

THOMAS TESCHE

Direct Examination By Mr. Fine 2087

DEFENDANT'S EXHIBITS:

NUMBER	ADMITTED
273	2110
274	2110
275	2107

P R O C E E D I N G S

THE COURT: Mr. Fine, I understand you were reprimanded yesterday for being late.

Did you have an appropriate response?

MR. FINE: Your Honor, I did not oversleep, Your Honor, as Madam Clerk intimated to me later in the day. I was working on other matters in the courthouse. I was just not present in the courtroom.

I hope that my absence was not a detriment to the Court's business.

THE COURT: No. She'll appreciate that explanation as being adequate, I think.

All right. We're ready to proceed then.

MR. FINE: Thank you, Your Honor.

The Tennessee Valley Authority calls as its next witness, Dr. Thomas Tesche.

THE COURT: All right, sir.

MR. FINE: Your Honor, we'll be working principally from book 13 of TVA's book of exhibits. Not exclusively, but primarily book 13.

THE COURT: All right, sir.

THOMAS TESCHE,

being duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. FINE:
Q. Would you please give us your name?
A. Thomas William Tesche.
Q. And where do you currently reside?
A. I live in Fort Wright, Kentucky.
Q. What is your current employment?
A. I'm a principal scientist with Alpine Geophysics, LLC.
Q. And if you could just briefly tell us what is Alpine Geophysics.
A. Alpine Geophysics, LLC, is a partnership that is engaged in air quality modeling, emissions inventory development, and application of models for regulatory studies.
Q. What is your understanding of your role in the case that we've been trying here?
A. I was asked by TVA to assist them in two aspects of the case. One was to evaluate the technical merits of the modeling set forth in the Chinkin and Wheeler expert report; and the second was to perform independent modeling to assess the air quality impacts resulting from two different control scenarios in the year 2013.
One was the scenario in which the Tennessee and North Carolina EGU fleets were subject to controls set forth in the Clean Air Compliance Act -- I'm sorry -- the Clean Smokestacks Act; and the second simulation was a condition of 2013 in which the TVA power plants would be operating in

accordance with their established plan.

Q. Dr. Tesche, would you please summarize the opinions you've reached in this case?

A. I have three main opinions as the result of my work in this case.

First, with respect to the modeling analyses set forth in Chinkin and Wheeler's expert report and their supplemental reports, I find that the combination of the overstatements of SO2 and NOx emissions from the TVA sources in the year 2013, combined with a rather fanciful construction of a modeling inventory for input into the CMAQ model that purported to reflect 2013 expected conditions but really reflected current levels of emissions at TVA that wouldn't change over the next six to seven years, led to a modeling output that was simply meaningless, meaningless in the context of understanding what these two different power plant scenarios would produce in the year 2013.

Second, I found that the modeling that the Alpine Geophysics and TVA modeling team performed provided, in my opinion, was a credible estimation of the air quality impacts for ozone, 8-hour -- 8-hour ozone, short term and annual fine particulate concentrations, visibility in sulfate and nitrate deposition that are credible estimates, notwithstanding the uncertainties that we expect in this type of modeling.

Thirdly, my conclusion finding is that the air quality

impacts for ozone and fine particulate in the year 2013 attributable to the further imposition of Clean Smokestacks controls on the TVA facilities, those that go beyond the TVA plan, will not lead to measurable or important air quality improvements relative to the 2013 base case.

In particular, for ozone, imposition of the Clean Smokestacks controls on the Tennessee Valley power plants would produce an ozone benefit of no more than 5 parts per billion in the extreme western portion of the state of North Carolina.

Now, that 5 ppb must be understood in the context of the modeled concentration in that locale on that day attributable to all the other sources in the region, including anthropogenic sources from North Carolina, all other sources in the southeastern United States, and emissions from the North Carolina fleet; and when you consider those concentrations together with the 5 ppb from the TVA facilities, the combined concentrations on the day when TVA's impact is high are well below the standard for even the newest ozone standards set forth by EPA.

Second point is that, with respect to fine particulate, PM2.5, on the annual average, the peak concentration that we determine through the CMAQ modeling as the result of additional controls on TVA was no more than .065 micrograms per cubic meter on an annual average, and that number would

be compared with the National Ambient Standard for fine particulate of 15.

With respect to that, that increment also occurred in western North Carolina in a grid cell that actually covered two-thirds -- of which Tennessee covers two-thirds of that cell. So it was a sliver of land in North Carolina for which an impact of .065 micrograms was predicted as the maximum impact associated with additional controls from Clean Smokestacks, and that increment is well below the significant thresholds for fine particulate and well below the measurement levels of the current monitoring capability of PM2 instruments.

So, in summary, my findings are, for those three elements, that the credible modeling using current state-of-the-science models and updated inventory suggests that the additional controls called for in the Clean Smokestacks Act to be applied to Tennessee Valley sources will not produce any meaningful or significant air quality benefits within the boundaries of the State of North Carolina.

MR. GOODSTEIN: Your Honor, if I could be heard for one minute. I don't want to interrupt the examination any more than I have to, but we have stipulated to Dr. Tesche as an expert on atmospheric sciences, but our understanding was that Dr. Tesche is not going to be offering opinions about

the accuracy of the emissions estimates prepared by TVA. In fact, at his deposition he expressly disqualified himself from offering any kind of opinions about the accuracy and the methods used by staff of TVA to come up with the 2009 and 2013 emissions estimates, and so we need to note our objection to Dr. Tesche testifying about the accuracy or appropriateness of the emissions estimates, since at his deposition he made it very clear that he is not prepared to testify to the accuracy and the methods used by staff of TVA to come up with the 2009 and 2013 emissions estimates. "That was not within my purview," per his testimony in his deposition.

MR. FINE: Your Honor, there is no dispute that Dr. Tesche and his modeling team used in their modeling the projections of TVA staff as to TVA emissions that were anticipated for 2013.

Dr. Tesche, of course, was present here in the courtroom yesterday during Mr. Scott's testimony. While we're not going to be asking him to attest to the accuracy of TVA's emission projections for 2013, he did use those numbers in the modeling that he and his team performed. But I think that Mr. Scott spoke with some eloquence about how those emissions estimates were prepared.

THE COURT: All right. I will overrule plaintiff's objection, and I trust the results of careful

cross-examination to be of benefit to the Court in making a final analysis.

MR. GOODSTEIN: Thank you, Your Honor.

MR. FINE: Thank you, Your Honor. And as Mr. Goodstein has indicated, plaintiff has stipulated that Dr. Tesche is an expert in atmospheric sciences, and a stipulation that TVA appreciates. However, as with North Carolina's witnesses, we will explore some of Dr. Tesche's background so the Court will have an understanding of Dr. Tesche's credentials in terms of weighing his evidence.

THE COURT: Yes. Let the stipulation appear of record, and I will, yes, expect you to bring out some of the background of the witness.

MR. FINE: Thank you, Your Honor.

Ms. Shea, will you do me the kindness of displaying Exhibit 275 on the display.

And, Dr. Tesche, if you'd please turn to book 13, which is there by you on the witness stand, and turn to Defendant's Exhibit 275 in that book.

Do you have it, sir?

THE WITNESS: Yes, sir.

BY MR. FINE:

Q. Dr. Tesche, would you please summarize your educational background?

A. I received a bachelor's degree in mechanical engineering

from the University of New Mexico in 1969; I received a master's degree in engineering from the University of California at Davis in 1971; and I received a Ph.D. from the University of California-Davis in 1974. That degree was in environmental engineering.

Q. And I believe, Dr. Tesche, that your educational experience is set out on page 3 of Defendant's Exhibit 275?

A. Yes, sir.

Q. Dr. Tesche, Defendant's 275 also lists, generally, your work history on page 2?

A. Correct.

Q. Could you briefly, sir, just go over your work history?

A. I worked for four different national laboratories in the time I was engaged in my college studies. Once I got my Ph.D. from the University of California, I went to work immediately for Systems Applications, Incorporated, in California. SAI. And they were the firm selected by EPA to develop the first generation photochemical grid model that was the grandparent, you might say, of the current-day models, such as CAMX and CMAQ.

I worked at SAI for 12 years, reaching the level of manager of the advanced modeling and applications group. During that period of time, I participated in virtually all aspects of the development and testing of the urban airshed model, including the emissions processers, the meteorlogical

processers, the chemical kinetic mechanism, numerical methods in model evaluations, and I participated in virtually every model application study that SAI performed over that dozen years in my role there.

I then went to Radian Corporation, but in parallel with that, I was teaching at the University of California, Berkeley and Davis campuses. I was an adjunct professor and taught advanced graduate level courses in atmospheric modeling.

While at Radian, I was involved in developing advanced geologic modeling. One was the urban airshed model for application to SIPS and the other was to begin work on global climate modeling using the National Center for Community Climate Modeling.

I formed Alpine Geophysics, my present company, in 1985 while I was still with Radian, and for the ensuing five years while I was employed at Radian I also worked at Alpine Geophysics but in a capacity that was non-competitive with my efforts at Radian.

I joined -- or I went to work full time for Alpine Geophysics in 1990, and for the remaining 22 years, or whatever that is, I've been fully engaged in atmospheric modeling, regulatory studies, and model development with Alpine Geophysics.

Q. Dr. Tesche, what sort of clients have you worked for in

your work with Alpine Geophysics?

A. I would say my mix of clients at Alpine Geophysics is roughly balanced between public and private sectors. We do a fair amount of work for USEPA as a contractor. We do work for state agencies. We have done a lot of work for the regional planning agencies. You've heard of VISTAS. And several other regional planning organizations we've done a lot of work for in connection with database development such as we've used in this case.

We have done a lot of SIP modeling work for municipalities as well.

Q. When you say SIP modeling --

A. Yeah. State Implementation Plan modeling for 8-hour ozone and fine particulate for state agencies, such as Texas and California and so on.

On the other side, in the private sector, we've done a fair amount of work for the electric power generating sector, for research groups, such as EPRI, the Electric Power Research Institute, which coordinates research for the electric utilities in this country.

We've done a lot of modeling work and participation in SIP studies, ozone and fine particulate, for the petrochemical industry in New Jersey and Texas and elsewhere, helping them in the process of working with state agencies to develop regulatory plans for air pollution control.

We've done a lot of work in the permitting of individual power plants, to help them comply with the requirements of prevention of significant deterioration and New Source Review, assist them in getting the permits they need in order to operate new generation in various states.

Q. Dr. Tesche, if I can draw your attention to the listing that begins on page 4, the document that's been marked as Defendant's Exhibit 275.

A. Yes.

Q. And I believe that this is a compilation of your recent publications, or a start of a compilation of your recent publications.

A. That's correct. This is a compilation of the professional reports, peer-reviewed journal articles, presentations at public meetings and conferences that I have given over the last ten years or so.

Q. I'm assuming, Dr. Tesche, this does not represent your entire professional output.

A. No. The last time I counted this, and this was a few years ago, the total number of distinct reports and papers and articles was over 350, and I stopped counting then.

See, in my business as a consultant, we're evaluated by our clients on the basis of the number of technical reports we write, and on any big projects, such as VISTAS, there are maybe a half a dozen important reports on different subject

matters that get written as part of the study that become stand-alone technical reports, and so it's not too terribly difficult to produce a lot of documentation of the work done in big studies, and a good part of my publication record is filled by that type of documentation.

Q. Again looking at page 4 of Defendant's 275, sir, I notice professional certification as a certified consulting meteorologist. You see that, sir?

A. Yes.

Q. Could you explain to us what that is?

A. I believe Mr. Wheeler gave the Court a brief overview of what the certified consulting meteorologist program is. Essentially, it was a program established in the mid 1950s by the American Meteorological Society to provide a distinction for its consulting fraternity, men and women who had displayed exceptional skill and integrity and competency in their particular disciplines in meteorology.

To be awarded a certification of -- a certification as a consulting meteorologist one needs to successfully go through oral interviews, a background check with clients, written tests and an oral test prior to being adjudged as to whether one is worthy of receiving that certification.

Since the mid '50s, I believe there has been about 700 men and women that have been so certified. Obviously, not all of them are active today. I think there's maybe 200 or

220 active today. And that could be compared with the number of men and women that have been involved in the American Meteorological Society over the last half century. And I don't know what that number is, but it's large.

Q. When did you receive that distinction?

A. 1988.

Q. What other professional memberships do you have, Dr. Tesche?

A. Over the years, I've participated actively in several professional memberships. They would include the American Association for the Advancement of Science, the American Geophysical Union, the Air and Waste Management Association, American Society of Civil Engineers, American Society of Chemical Engineers, and the American Chemical Society. I may have duplicated a name or forgotten one. Presently, I maintain active membership in three of those, the American Geophysical Union, and Air and Waste Management, of which I've been an active member for 37 years, and the American Meteorological Society, with whom I've been involved for over 30 years.

Q. Dr. Tesche, I'd like to draw your attention briefly if we could to page 2 and 3 of Defendant's Exhibit 275 under the heading of "Areas of Professional Expertise." I don't want to go into this in too much depth and detail at this time. Does this set out the areas of expertise that you have --

that you have worked in?
A. It does.
Q. And just a very briefly, if you could give us an understanding of what it means to have expertise in regulatory application of photochemical models for attainment demonstrations.
A. I've been involved in the development and application of photochemical models since they were first constructed in the early 1970s, and as part of that effort, I've been very heavily engaged in applying grid-based and Lagrangian-based models to help federal and state agencies develop plans for ozone and PM control, and I've carried out that kind of regulatory work in, gosh, over 30 cities and regional areas around the United States.
Q. If I could direct your attention to the next item, atmospheric model development, testing and refinement. If you could give us some idea of what that involves.
A. The actual model development goes hand in glove in the application of these emergent models in a regulatory setting. As I said in the beginning, the tools that we were using were just being developed, and over the space of a 30-year career in this area, I've been continually involved in the development, refinement, and especially the testing of the emissions part of these models, the meteorlogical part of these models, the chemical kinetic mechanisms to treat the

reactions in the atmosphere, and especially in the software that we use to evaluate the models and to test their uncertainty.

All of that I put under the category of model development and testing. It's a very necessary component of applying these models in a regulatory framework.

Q. The next item is model evaluation and uncertainty analysis. Again, sir, I call on you to briefly explain to us what that entails.

A. It entails comparing the model predictions of the estimates coming out of models, not just the air quality model, but the emissions models, meteorological models, the land surface model, and all of the computer modules that make up the modeling system against atmospheric data, measurement data, at the ground and aloft and wherever one can gather it up, to try and find if there is evidence of flaws or uncertainty or bias in the models.

There is -- it's not so much a desire to prove that the models are right but, from a scientific perspective, to see if we can find examples where the model is not performing well. And that's a subtle difference and objective. We're not trying to validate models. As part of this process, we're trying to see if there are flaws in the modeling, and if there are, we try to remove them.

So, finally, model acceptance for regulatory

applications derives as the result of successive non-rejection of models when we test it with the data sets we have. So we build confidence through successive testing that these models are the best we can do. And that is the core theme in the model evaluation that I've been involved.

Q. Dr. Tesche, moving down a little further on page 2, I note the entry "Air Quality and Meteorological Data Analysis." Again, sir, if you could exculpate what's involved with that briefly.

A. Well, that heading should also include emissions data. But what that heading refers to is the obvious need to analyze and understand the myriad of emissions and air quality and meteorological data that one has to master, both in terms of the content -- you need to understand the processes -- as well as formulate it in a process that goes smoothly into the regulatory models without creating mistakes.

So this description of skill and expertise in the area of data analysis is part and parcel to the process of understanding models, applying them soundly, testing them appropriately, and then presenting their results in a believable context.

Q. Turning over to page 3 of Defendant's Exhibit 275, there's an entry, "Modeling In Complex Terrain/Complex Meteorological Settings."

Dr. Tesche, could you help us understand what that involves?

A. Early in my career, in the '70s and '80s, there was a real strong push in the United States to improve the simulation capability of models in very rough topography. It was driven in part by the excitement over oil shell development in the western United States, and it was recognized by DOE and a number of others that those were areas where the terrain and meteorology were very challenging, and the modeling tools at that time were very limited, and so they ensued a major program in this country to develop complex terrain models, and part of that was the performance of tracer diffusion studies in the western United States and then the evaluation of those models in complex terrain against tracer data.

And I was very heavily involved in programs for the Department of Energy and for the energy department of California and a number of public power producers and private power producers in California to verify and prove those dispersion models.

Q. And, finally, for the purposes of your testimony here today, I note the category "Emission Control Strategy Formulation and Testing." If you could please explain that, sir.

A. Apart from the enormous scientific intrigue in building

these complex models, which is probably more academic, the purpose for which we were building these models, the reason EPA was funding this development was so that we would have predictive tools for estimating future impacts of pollution control programs from a variety of sources for a variety of pollutants.

We started out with ozone, but the field now has broadened to fine particulate and mercury and visible regional haze and so on. But the core theme was the development of these complex models that would allow us to make best estimates of the future effects of emission control programs, and you can't test an emission control program soundly unless you understand what makes up the general range of emission source categories and the levels of control that might be possible on those categories.

Now, I don't propose myself as an expert in control technology. That is not my expertise. But others with that skill are involved in providing their estimates of levels of control that might be achievable with different technologies on different source categories.

So as a modeler doing regulatory studies, my charge is to composite emission inventories that will reflect the level of controls on the different source categories, model them in the future, and then devise ways to reveal through the modeling output what the projected impacts might be of those

controls.

And often we find that the controls aren't sufficient to achieve the desirable air quality goals. And, normally, that's a federal National Ambient Standard. In that situation where we have modeled nonattainment, we must go back and seek out those emission control tactics that seem most attractive for reducing the pollution at the point where it's needed most.

So that's part and parcel of the development of emission control strategies and testing.

Q. Dr. Tesche, one of the models that's been used, I believe, both by STI, Mr. Wheeler and Mr. Chinkin's firm and by the team that you were working with on behalf of TVA, used the CMAQ model.

A. Yes.

Q. And just, if you could, what does that acronym stand for so we can move on?

A. CMAQ is the Community Multiscale Air Quality model developed by the EPA and number of researchers worldwide.

Q. What experience do you have working with the CMAQ model?

A. I was a peer reviewer for CMAQ in the late '90s at the time it was just about to be released. Our company was one of the first to exercise CMAQ when it was formally released. We used it in Lake Michigan, inter-comparing it with CAMX, using two different meteorological models against the Lake

Michigan ozone study databases that I helped design and manage. Those databases provided measurements at the ground and aloft for several episodes, and we used those data to evaluate CMAQ -- this was in 2001 -- and compare it with CAMX and do a very detailed inter-comparison performance evaluation.

Since that time, I've personally run CMAQ myself, and others in my staff have, in a number of settings around the country, especially for VISTAS, and in subsequent studies of the CAIR model. We've done, actually, a repeat of the CAIR modeling with CMAQ.

Q. Dr. Tesche, you referenced, I think, another modeling system called CAMX. Would you tell us what that acronym stands for?

A. CAMX means Comprehensive Air Qaulity Model with Extensions.

Q. And did the team that worked with you in this case use CAMX modeling as well as CMAQ modeling?

A. We did. We used both of them jointly.

Q. And could you explain -- excuse me.

Would you describe your experience with the CAMX modeling system?

A. CAMX has its roots in the original urban airshed model that I was a co-developer of in the '70s and '80s. CAMX in its current incarnation is a product of the Research

Environment Corporation. They released that model publicly in 1998, and because of our close relationships with their scientists, we were selected as their first beta tester of CAMX. So our company, Alpine Geophysics, was the first group to be using CAMX outside of the developer. So we've been using it as early as the OTAG process.

Q. What is the OTAG process, Dr. Tesche?

A. The Ozone Transport and Assessment Group, a large multistate effort in the late, gosh, late '80s, I think. It was a long time ago.

But it's purpose was to look at regional transport from one state to another, and it was the foundation for the NOx SIP Call, the modeling that was the foundation for the NOx SIP Call, and that used the CAMX model in part.

Since that time, I've been actively involved in CAMX modeling in a large number of the SIP studies that we've done for state and local agencies. I think it's fair to say that I and my associates at Alpine have run CAMX for more cities in more situations than any other firm or individual in the United States today. And that includes the developers at Environ.

MR. FINE: Your Honor, I'd ask that Defendant's Exhibit 275 be admitted into evidence.

THE COURT: Let it be admitted.

(Defendant's Exhibit Nos. 275 received in

evidence.)

BY MR. FINE:

Q. Dr. Tesche, did you participate in the preparation of expert reports in this case?

A. I did.

Q. And I'd ask you to please turn to Defendant's Exhibit 273 for identification.

A. Yes.

Q. And could you tell us what this document is?

A. This document is the expert report that Steve Mueller from TVA and myself directed. We developed the technical approach to be carried out. We personally carried out a good portion of the analysis and interpretation, a lot of writing, and we were supported by modeling staff under our direction at Alpine Geophysics and at TVA.

Q. And what level of knowledge do you have of the contents of this report?

A. I've read this report and provided my technical comments on every aspect of it.

Q. You have reviewed this report?

A. Yes, sir. And several drafts of it.

Q. What steps have you taken to assure yourself of the accuracy of the contents of this report?

A. Well, I had the opportunity to evaluate the tabular summaries and graphical displays of all the modeling that

Alpine did for our portion of the work personally, because I have that on my computers in my office. So I was able to verify the information Alpine was putting in this report was correct.

I was able to review the text and the graphics and request additional analyses and plots to explain what was already provided by TVA in the report so that I would fully understand the details and the justification for the material they contributed.

So I believe that, through those efforts, I am confident in saying that I can attest to the soundness and correctness of this report to the best of our ability.

Q. And if you'd turn very briefly to the document that's been marked for identification as Defendant's Exhibit 274.

A. Yes.

Q. And again, sir, what is this document?

A. This is a supplemental report that we prepared in response to questions that were raised by Chinkin and Wheeler regarding our first expert report.

Q. And was your role the same as with Defendant's Exhibit 273?

A. Yes.

Q. And again, sir, what steps did you take to be able to assess the accuracy of the information contained in this document?

A. Well, I think the characterization of the steps I took on the expert report that I just explained for you are the same steps I would have taken here.

MR. FINE: Your Honor, I'd ask that Defendant's Exhibit 273 and 274 be admitted into the record.

THE COURT: Let those be admitted.

(Defendant's Exhibits 273 and 274 received in evidence.)

BY MR. FINE:

Q. Dr. Tesche, in response to one of my earlier questions, you mentioned an organization called VISTAS, and I think we've heard a great deal of testimony about VISTAS, but could you explain what your involvement was with VISTAS?

A. I was one of three co-contractors in the VISTAS emissions model, or emissions air quality modeling team. It was a team of three contracting groups, Alpine Geophysics, Environ Corporation International and the University of California at Riverside.

Q. Dr. Tesche -- and I apologize for the interruption, but neglected to ask you, just very briefly, if you could tell us what VISTAS is.

A. VISTAS is one of four regional planning organizations that was commissioned by -- excuse me, one of five organizations commissioned by EPA in response to the Regional Haze Rule. And the purpose was to allow the states on a

sub-regional basis to work harmoniously together in the development of modeling and data tools to allow them to put together a regional haze SIP, and information for the states to do the same, that would address the year 2019 interim target of the Regional Haze Rule.

Q. And before I so rudely interrupted you -- and I apologize again -- you were explaining your involvement with VISTAS.

A. Yes. VISTAS issued a request for proposal that was seeking a contractor or contractors to provide the emissions modeling and the air quality modeling to support VISTAS. That was one of several contractor groups they needed help with. And the team of Alpine Geophysics Environ and University of California at Riverside teamed together and were successful in that procurement.

As leaders of each company, myself at Alpine, Dr. Gale Tonisson (phonetic) at the University of California, and Mr. Ralph Morris at Environ, were the three co-principal investigators, and our roles, including the management and technical oversight of our staffs at our individual institutions, was to work cooperatively in the creation of the emissions modeling and air quality modeling data sets and written products that were asked of us by VISTAS to produce, and this included both base year modeling for some annual base year. It involved developing emission inventories for

the 2018 future year, testing the models, developing the models in some cases, and carrying out future year control simulations to examine the sensitivity of the models, and to make visibility assessment -- visibility assessments with the models to examine progress towards the future regional haze goals.

Q. What's the relationship between the VISTAS effort and the modeling that you and the team that you participated in conducted in this case?

A. The VISTAS modeling was foundational. At the time that TVA and Alpine undertook the present study to analyze the year 2013 impacts of the TVA plan and the Clean Smokestacks plan, we first asked ourself what is the most technically sound up-to-date peer-reviewed database out there that could be used to assess this question, and there was no doubt that the VISTAS database met that requirement far better than any other database in the country.

I think that the VISTAS modeling stands head and shoulders above the modeling that, in my opinion, has ever been done in this country for looking at regional ozone and fine particulate. It was directly applicable to the domain that we're interested in here. It had produced a suite of modeling tools, emissions, meteorological and air quality that have been very thoroughly evaluated, and the base case episode was adjudged to be an appropriate episode for

examining the impact of future power plant controls.

Q. What was North Carolina's involvement in VISTAS, if you can tell us?

A. Well, North Carolina was one of several states that were partners in VISTAS, but beyond that, and importantly beyond that, the senior management in VISTAS and the technical scientists and engineers -- excuse me -- the management of the North Carolina Division of Air Quality and the engineers and scientists in that group played a very significant and contributory role to the VISTAS program. Mr. Brock Nicholson, Ms. Sheila Holman, and other members of the Division of Air Quality were instrumental in providing guidance to VISTAS and sharing their experience and expertise in a large number of areas, together with making management decisions on certain issues that our science team brought to them for resolution.

So North Carolina played an essential role in producing the quality of the databases and the models that VISTAS now enjoys.

Q. Dr. Tesche, there's been some testimony concerning what I'm going to call the predecessor group to VISTAS called the Southeastern Appalachian Mountain Initiative. Are you familiar with that organization, generally referred to as SAMI?

A. I am.

Is there more water?

MR. FINE: Madam Clerk, if I could ask you to help Dr. Tesche?

(Pause.)

THE WITNESS: Yes, I'm familiar with SAMI.

MR. FINE: Madam Clerk, thank you for your assistance, and to the court security officer as well.

BY MR. FINE:

Q. Dry work, Dr. Tesche.

A. I'm sorry?

Q. It's dry work.

A. Exhilarating.

Q. What, if any, role did you have with SAMI?

A. I was involved in SAMI for a fair amount of that project's lifetime. I certainly wasn't, you know, one of the principal investigators, but I had the opportunity to contribute to SAMI from pretty much the beginning of that program.

I played a role in helping to write the air quality modeling protocol for SAMI. I wrote text in that protocol. I wrote a part of the text in the emissions modeling protocol in SAMI, which is the EMS-95 emissions model.

At some point in the SAMI process I was involved along with TVA to help build three new SAMI episodes that were woven directly into the SAMI process.

I personally evaluated all nine of the SAMI model episodes for meteorology. I did a detailed performance evaluation of the meteorology over the southeastern United States for all nine SAMI episodes and made recommendations as to which of the episodes were performing efficiently well for ozone and particulate modeling.

Our company was charged with doing the performance evaluation of three of these SAMI episodes. We were also involved in developing the future year 2010 and 2040 emissions inventories, the control inventories that we used for SAMI. This is the processing of the emissions through the EMS-95 model to go into the air quality models. We didn't do the preparatory work of rounding up control estimates and things of that nature. And we also analyzed the output of the control strategy.

Q. What role, if any, did you have in developing the actual emissions inventory that SAMI used?

A. My role was supervisor. That work was done -- the actual EMS-95 emissions modeling was performed Jim Wilkinson, a partner in Alpine Geophysics, done at a time when he was a joint partner in Alpine as a Ph.D. student at Georgia Tech, and my role with the SAMI emissions development process was to provide oversight to Jim and help him address technical questions that came up. I didn't have my hands personally on the data in that instance.

Q. What about the actual information that was being fed into the emissions processing system, the actual emissions inventory?
A. I had only general knowledge of that information.
Q. Was someone else responsible for assembling that?
A. Yes. SAMI had an emissions contractor whose job was to round up the foundational emissions data from the states and so on to provide to Alpine Geophysics for use in its modeling to produce air quality model ready inputs.
Q. When was the SAMI modeling done?
A. In the late 1990s and early 2000s.
Q. And what was the age of the data that was used for the inventory information?
A. The foundation inventory for SAMI was the 1990 USEPA National Emission Inventory.
Q. Is that information now somewhat out of date?
A. Well, it probably is still a reasonable approximation for what 1990 looked like. But in terms of it's current characterization of present conditions, no, it's out of date.
The other aspect of that is that that inventory was as good as could be created in those days with the technology and the understandings that people had.
But emission science has matured dramatically over the last decade and new sources of air pollution have been uncovered, better ways of quantifying and characterizing

emissions have been developed, and certainly better processing techniques for transforming raw emission estimates into the kinds of formats that are needed for sophisticated regional models have been improved dramatically, including the quality assurance of those data so we can weed out errors and emissions before they get into the air quality model.

Q. What modeling system was used in the SAMI effort, if you know?

A. That was the 95 EMS model, Emissions Model 95.

Q. Is that still the state of the science?

A. No.

Q. What is now?

A. The SMOKE model, S-M-O-K-E, Sparse Matrix Kernel Operating on Emissions, or something very close to that.

Q. Is the SMOKE model the one that was used for the modeling that you and your team performed in this case?

A. In VISTAS and in the TVA analyses that are the subject of this proceeding, yes.

Q. Was the modeling system that SAMI used somewhat analogous to either CMAQ or CAMX?

A. Yes. The URM-1 Atmosphere -- "URM" stands for Urban to Regional Model. "1 Atmosphere" refers to the landmark or distinguishing hallmark of that model, that it was the first time really in this country that people had been successful in integrating oxidant chemistry, that is, the chemistry of

ozone and hydrocarbons and NOx formation in the atmosphere, along with the dynamic processes that form PM2.5 in the atmosphere.

Before that time, people had not been successful in modeling both PM and ozone as one consistent atmosphere, and that was really a distinguishing feature of the science in the URM model and one of the hallmarks of the SAMI program.

URM was used at that time with the science available in those days to produce a modeling system that could predict ozone and fine particulate as they interacted with one another over the space of the SAMI domain.

Q. Was the current status of the URM modeling today's modeling science area?

A. Well, the developers of URM, particularly Dr. Ted Russell at Georgia Tech, have moved on to other models, especially CMAQ. I think he uses CAMX occasionally, but they've moved on and don't use URM anymore.

I'm not aware of anyone in this country or abroad who is using URM in any regulatory or even in any research application. My understanding is the model is still used at Georgia Tech for educational purposes as part of training for atmospheric sciences, give the students the model and let them run it, because it runs quickly on small databases and it's a very useful learning tool.

Q. The SAMI modeling -- I believe you testified that one of

the things you do for the SAMI effort, or in conjunction, I think you said, with TVA was to build three more modeling episodes for SAMI.

A. Yes.

Q. What sort of modeling episodes are we talking about, Dr. Tesche, in terms of the extent -- in terms of the time represented by them?

A. I don't remember the exact dates. I can get that quickly. But they were three one-week long episodes, or thereabouts. The SAMI episodes were all about a week in duration.

Q. And why were they -- how many episodes did they end up running?

A. SAMI built nine and ended up using seven, I believe.

Q. And these were just for one week --

A. Well --

Q. -- for each episode?

A. Four days, seven days, eight days. They were all of slightly different duration, but all about a week to -- five days to a week in duration, between the years 1991 to 1995.

Q. And if you know, sir, why were these episodes limited to the, roughly, week period of time?

A. The computational hardware available to the modeling community in those days was substantially limited compared with what we enjoy now. And SAMI wanted to run the models

over the entire annual cycle but could not. The horse-computing power simply was none. And so SAMI was forced to follow a method developed by EPA a few years earlier in the Radian acid rain program in which they modeled a number of episodes and then tried to fabricate an annual average on the basis of linking these individual episodes together and weighting them climatologically according to their frequency of occurrence throughout the annual cycle, and in such a way composite what looks like an annual average for PM10 based upon more detailed information from the five to seven-day concept.

Q. What has happened to computing power since SAMI's era?

A. Well, the power of computers has just grown astronomically.

What we longed to do in the old days was to run the model for the whole year, and we can do that now in just a few hours on a home-built computer.

MR. FINE: With the Court's permission, Your Honor, I need to approach Ms. Shea, my paralegal, to correct an error that I made. Lawyers make mistakes; paralegals don't, of course.

THE COURT: You may.

MR. FINE: One of the difficulties, Your Honor, of writing things late at night is transposing numbers.

I'd ask that Ms. Shea display a document that's

previously been introduced into evidence as Plaintiff's Exhibit 135. I believe that's up on the screen.

BY MR. FINE:

Q. Do you have that in front of you, Dr. Tesche?

A. Yes, sir.

Q. And what is it that is displayed in Plaintiff's Exhibit 135?

A. This map displays a nested CMAQ modeling domain consisting of an inner 12-kilometer mesh, the blue lines, and a parent 36-kilometer mesh. When I say 12 or 36, I mean that in the sense that the 12k domain consists of an array of a large number of grid cells, each with a horizontal spacing of 12 kilometers on the side. And the 36-kilometer domain is composed of an array of a large number of grid cells, each with a spatial dimension of 36 kilometers on the side.

Q. Is the 12-kilometer domain nested within the 36-kilometer domain?

A. Yes. It fits harmoniously by a three-to-one nesting scale into the 36k domain.

Q. Is this the unit used by the VISTAS modeling?

A. Yes, sir.

Q. Both the 12k and 36k domain?

A. Yes, sir.

Q. And how do -- Mr. Wheeler has explained some of this, but just so that we can put your testimony in context, how do

you, as a modeler, use these domains? How do you build them, and what goes into using them in a computer modeling exercise?

A. Well, let me first add that what you're seeing here is the ground-level footprint of the modeling domain, but what you don't see is the layers of the grid cells aloft.

So there is a corresponding layering of grid cells in the vertical dimension going from the ground up to, say, the height of the clouds. So there is various layers in the model, together with this mixture of grid cells.

The first thing that one does in compositing a domain is to really ask themselves what are -- you know, what's the air quality issue I'm trying to address, and in the case of the current TVA program, but especially VISTAS, which was the author of this domain, the issues concerned both 8-hour ozone and annual average fine particulate. And those two chemical species have similar but not exact behaviors in the atmosphere in terms of lifetimes, origins of the pollutants that form them, their rates of removal and so on.

So first you have to understand the air quality problem you're dealing with and its spatial extent and the types of sources that are relevant to be included directly in your modeling.

And along those lines, while the focus of the VISTAS modeling and our TVA modeling was on the southeastern United

States, we recognized that there is considerable transport into the VISTAS domain from other states in the United States. That was one of the lessons learned in SAMI, and VISTAS built upon that knowledge. And so a 36k domain was established that included the large emission rates in northern Canada -- excuse me -- southern Canada and northern Mexico.

Q. Dr. Tesche, was there any effort made to understand contributions from the areas that are outside the red box that's outlined in Plaintiff's Exhibit 135?

A. There was a very focused effort.

Q. And could you describe what that effort was, in general terms?

A. At first blush, one might think that by modeling an area the size of what you see depicted here might be sufficient to characterize the concentrations of material flowing into the red domain -- excuse me -- the blue domain. Or even the red domain. After all, that covers a lot of area, and our focus is really the VISTAS states, Tennessee and North Carolina.

But the fact is that intercontinental transport of emissions is something that needs to be accounted for, particularly when we're dealing with the lowering of air quality standards.

What we have found is that transport from other countries can cross this red boundary and have an effect on

air pollution concentrations in the interior blue domain. Perhaps not a big effect, but we're using these models often in a differential sense to look at the effects of different control strategies in a future year, and that's precisely what the Alpine/TVA team did in this proceeding.

And since you're looking at smaller quantities, it's far more important to make sure you can model those correctly. And if they're influenced by some amount of transport coming in from an outside source that you're not accounting for, like the huge power plants in Mexico that are virtually uncontrolled right along the Texas border, you want to be able to somehow incorporate them into your model.

The way that we have done that -- and this was a novel step done by the VISTAS management -- was to commission Harvard University's global modelers to run their global chemistry models in a way to provide boundary conditions to the red area. So that we had a chemically consistent hand-off from the larger continental or hemispherical scales down to the regional scale in red, to the more local scale in blue, to remove the uncertainties that SAMI was vexed with in trying to prescribe boundary conditions for its domain, which was about the size of this blue 12k box.

Q. You mentioned some issues that SAMI had with boundary conditions. I don't want to get into that in any detail at this point. But did SAMI, itself, discover that there was

long-range transport material?

A. I don't think they discovered that directly, but the folks doing the SAMI work were knowledgeable modelers and they understood the boundary conditions. They just didn't have the time and resources to do the kind of hemispheric modeling the VISTAS did. They tried to address it as best they could, but they essentially defaulted to the practice common in those days, which was to estimate boundary conditions, say along the perimeter of this blue area, by simply pulling measurements out of the EPA air quality measurement base, interpolating them across the ground, and then, assuming that those concentrations fully define the load of pollution coming into the SAMI domain.

They had no aircraft data, no regional models to tell them how the pollution varied aloft, and so they simply linearly interpolated up to a clean atmosphere.

So I think they recognized that they were not treating the boundary conditions in an ideal way and it was introducing -- well, it was introducing uncertainty into their modeling, but there wasn't a better alternative available to them at that time.

Q. Dr. Tesche, just one other aspect of this I'd like to get into for a moment or two. I think that you explained to the Court that what we're looking at here is the horizontal -- when we're talking about 12-kilometer or

36-kilometer grids, that's the horizontal measurements of the grid; is that correct?

A. That's correct.

Q. And I think you alluded to the fact that there are vertical slices to the atmosphere as well?

A. Yes, sir.

Q. In the VISTAS modeling, what were those vertical slices?

A. The VISTAS modeling had 19 different layers, beginning at the ground and going up to around 14,000 or 15,000 meters in the atmosphere.

Q. 14, 15,000 meters in the atmosphere?

A. Correct.

Q. About the height that an airplane might fly?

A. Well, part of it is landing pattern. I think most of the big jets, when you're going across the country, are running at 32 or 35,000. But, you know, 15,000 meters certainly is sort of in the range when you're beginning to come into a city.

It's kind of about the level of the base of the large cumulus clouds that you see. You know, when you come in through the clouds and all of a sudden things get kind of bumpy, you're sort of at the top of the model domain. At least the VISTAS domain. SAMI was a little bit lower. They only had seven layers.

Q. SAMI had seven and VISTAS had 19?

A. Yes.

Q. And with those vertical slices, are they of equal height?

A. No. They're staggered in height to provide the greater resolution near the ground, where things are -- where there are greater sources of air pollution and you want to account for their quick-count reactions and so on. The cells get thicker as you go aloft.

MR. FINE: Thank you, Ms. Shea.

BY MR. FINE:

Q. Dr. Tesche, I'd like to turn your attention, if I could, sir, to the question of emissions inventories used in, I guess, most of VISTAS modeling and then in the TVA/Alpine Geophysics modeling in this case.

If I understood answers to some of my earlier questions, your modeling effort here used the basic VISTAS inventory of emissions?

A. In virtually every instance except power plants in North Carolina and TVA, we used the VISTAS inventory, yes.

Q. We'll cover the modifications you made to that in a moment, but in terms of what I'm going to call sort of the basic information, it was drawn from the VISTAS inventory?

A. That's correct, we did use the VISTAS inventories.

Q. Could you explain to us how VISTAS went about building the inventory?

A. To begin, VISTAS understood the reality of inventory development, that it's a time-consuming process and one that is peppered with various versions of the inventory as new data are introduced, as quality assurance reveals better ways to do things or errors in the original compilations.

VISTAS had contractors that were working with the states, state agencies and EPA whose job was to develop the basic emissions data for permits and things of that nature. These contractors had the task of assembling all of the foundational emissions data for a whole variety of source categories and put it into a form that could be transferred to emissions modelers, such as our group, that could further process that data and put into the air quality models.

So VISTAS had a team of inventory specialists who really were adept at working with state agencies and knew the processes and controls and the procedures for compiling the basic emissions data, and they worked very hard over several years to compile inventories. And they compiled inventories in different renditions as time went on.

And as the modeling -- emissions modeling contractor, we also had several different versions of the inventory, beginning -- I think we had a base A. I can't recall. But there was a base C and then a D, and then an F, and then a G. So there were different inventories along the way and reflecting correction of errors. One inventory didn't have

offshore shipping in it. Ships are important, especially if there are big transport lanes right along the coast of North Carolina. Some emissions in our earlier inventories had double counted power plants. Well, these kinds of things were caught and removed in the subsequent inventories.

So when I say that we used VISTAS inventories, we did, but we didn't remain static, we moved forward, with emergent VISTAS inventories culminating in base G at the time we did our final modeling. So our effort was to take advantage of the final round of corrections as best we could, reflected in the VISTAS modeling improvement activities.

Q. Dr. Tesche, based on your expert disclosure reports, it's my understanding that you used VISTAS base F for the modeling you did for model year 2002.

A. That's correct.

Q. But you moved to VISTAS base G for the modeling you conducted for model year 2013?

A. Yes.

Q. I'm assuming that base G became available somewhere in that process?

A. Yes. As soon as it became available, we adapted directly to it, probably within -- well, we were -- we were the developers of the base G inventory -- at least our group was doing the processing of the base G inventory for VISTAS, so there was no hiccup in terms of us moving the TVA/Alpine

work to VISTAS. There was no delay in us moving to the corrected emissions.

Q. Once those were available?

A. Yes. We did clear this with VISTAS management to make sure that they were agreeable that we would use the most recent VISTAS data in this project, and they gave us their approval.

Q. Dr. Tesche, I don't want to spend too much time on this, but could you please describe why did VISTAS go from base F to base G?

A. Well, there's two ways you can quality assure an inventory. One is by looking at the emissions process as it's going on and producing the inventory, and looking at the quality assurance reports coming out of the emission processing model and see if it's barking at you in any way and warning something is wrong, to go check this part of the file. Or looking at the output of the emissions and looking at the spatial maps, the color plots of emissions, and saying, "Does that look right?"

And skilled modelers can discern problems with an inventory often with that kind of approach. But subtle problems, like a double counting of a power plant source, for example, or mislocating a power plant across a boundary or putting it out in the ocean, sometimes subtle things like that don't come up until you actually run the emissions

through the air quality model and analyze it from an air quality perspective.

So the joint use of air quality modeling and the traditional quality assurance methods combine to provide a pretty helpful tool in locating and ultimately correcting emissions errors.

The third part of that, though, is that when you provide these data sets to others and let new eyes, skilled new eyes look at the modeling, do their own calculations, they can find things amiss with the inventory that the first group might not see.

Q. Is that what happened in terms of base F, when you moved from base F to base G?

A. In many instances there were errors in the base G inventory that were identified -- excuse me -- errors in the base F inventory that were identified by the reviewing groups, and this includes both EPA personnel, but, more specifically, the men and women in the state agency, like Division of Air Quality, North Carolina, the various states, industries, who obviously had a stake in making sure that the emissions were correct. So there were a lot of people over the space of about a year that were looking at these.

There were other parts of the emissions inventory with respect to EGUs, but I think your intent was to probe that later.

Q. We've heard some testimony concerning a model called IPM?

A. Yes.

Q. And it's been referred to as an EPA model. To your knowledge, is it an EPA model?

A. That designation is incorrect. IPM is not an EPA model. IPM is a proprietary model owned by ICF Kaiser International. It has been a proprietary model since the days of OTAG, the late '80s. It's a model that, to my knowledge, no one has ever peer reviewed on the outside; no one has been given an opportunity to look into the code or test it independently, as people have with all the other models. And yet IPM, as a tool, figures prominently in EPA's OTAG modeling, the NOx SIP Call modeling, and CAIR, CAMR modeling, and even in the VISTAS modeling that you've heard me talk about, as well as the modeling by the other planning organizations around the country.

So IPM plays a central role. And it's a good tool for what it does, but it's not the only possible tool that could be used.

Q. Let me focus, if I can, on the development of base G inventories, or I should say in the review of base F. I'm assuming that, as you've testified, VISTAS used the IPM model to develop its inventories?

A. They did, yes.

Q. And in the review of base F, were there some problems discovered with the IPM information?

A. There were, yes. A number of changes were sought. Improvements to the IPM output were sought by the VISTAS and the Midwest Regional Planning Group, one of the four -- one of the five sister RPOs involved in this.

Q. And those were improvements incorporated into base G?

A. There was a significant effort by the Midwest Planning Organization and VISTAS to examine the output of the base D -- excuse me -- the base F IPM simulations and, working in conjunction with the electric power industry, identify where locally IPM was improperly assigning emission rates and generation capacity.

The IPM model is simply one model of what the emissions and power plants are going to look like across the country, and in some cases locally, they were quite correct, quite consistent with what owners thought their plants would be. In other cases, in Texas, they were showing no generation at all, which was news to the owner. Their power plant had been shut down.

In the VISTAS domain -- the VISTAS and the participating states had a real interest in getting it right, in making sure that the emission rates in the year 2018, and later in 2009, were as accurate as what the utilities were expecting their generations to look like in emission rates. And so IPM

was rerun and the output of IPM was modified by the states in VISTAS to reflect better knowledge, to ground-proof it, in a sense, to make it look more realistic in terms of what's expected in 2009 and 2018 in the southeast U.S.

It's that level of improvement that was made in the base G inventory that was never done in base F.

Q. Couple points I'd like to follow up on, Dr. Tesche.

I think you referred to the effort to look at emission rates and power plant controls in the future as part of the effort to build the emissions inventory.

A. Yes.

Q. What is the practice in your profession in terms of looking in future years in terms of emissions and control scenarios?

A. Well, step one is to look at what EPA says you should do. This is regulatory modeling that I'm referring to. And if we're going to do regulatory modeling, you want to understand what are the ground rules EPA sets forth if you're doing ozone and PM modeling for SIP. And the databases that we were developing in for VISTAS were intended just for that, for SIP inventories for ozone regional heights. So we looked at the EPA guidance on how to develop future year inventories to assess our quality of impact, and that guidance is very clear that when you build a future year inventory, you estimate to the very best ability that you have what the

emission rates are going to be in that future year.

So if your future year is 2040, you have to look into your crystal ball and make your very best estimate of what power plants or automobiles or dry cleaners are going to be doing in that out year, and those are very uncertain in some cases. But the bottom line is you estimate to the best of your ability what the actual nominal emission rates are going to be in the future year.

Q. And that would include factoring in pollution control plans from state electric utilities?

A. Precisely.

Q. Dr. Tesche, based on your review of the reports provided by Mr. Wheeler and Mr. Chinkin from STI, which VISTAS-based inventory did they use in their modeling?

A. They used base D.

Q. Base D?

A. Base D.

Q. Not base F?

A. I'm sorry. Yes, they used base F.

Q. But not base G?

A. No, they did not use base G. They used base F.

Q. Sir, there's been some, both testimony and certainly some fairly constant illusion, to the fact that the D.C. Circuit Court of Appeals has recently vacated EPA's Clean Air Interstate Rule.

Are you familiar with that development?

A. Yes, sir.

Q. And I'm assuming, sir, and please correct me if I'm wrong, that the controls that were to comply with CAIR be one of the sets of future controls that would be included in VISTAS future year inventories?

A. That's correct.

Q. Sir, if you can, in your professional judgment, what is the impact of the vacation of the CAIR rule on the modeling in this case?

A. At first glance, it might seem like a big deal, and in many aspects it is very important. Certainly it's important around this country in terms of our air quality planning. But my opinion is that, with respect to what TVA and Alpine have attempted to do in this case, it has, really, a fairly minor effect. And I say that because what we're focusing on in this case is the difference in impact in the year 2013 that derives from two different scenarios. Controls. Clean Smokestacks Act controls on TVA and the North Carolina fleet, versus Clean Smokestacks on North Carolina and the TVA plan on the TVA fleet.

So we're looking at a difference between two specific control scenarios, and that's the question we're trying to model. We're trying to provide insight as to what the air quality impacts of that differential are.

Now, CAIR and the controls associated with it are very important from the standpoint that they were foundational in the construction of the emission estimates throughout the entire United States, because those inventories were based with the assumption that we were moving towards CAIR controls. But we're trying to focus on the difference between two future power plant control scenarios, and so whether the resultant level of emission controls in all the other sources in all the other states are somewhat lower or somewhat higher is not, in my opinion, going to measurably change our modeled impact of this differential between two power plant scenarios. So in that context, our estimates of the incremental improvement, let's say, of the smokestacks controls on TVA are not really going to be affected numerically by the fact that maybe there won't be CAIR level controls in Nebraska or Ohio or other places like that.

I'm not saying that there is no effect. Don't get me wrong there. But I believe that the difference between the two future year power plant scenarios that we're examining here, I don't believe they're going to be materially influenced by different assumed CAIR levels.

The fact is, no one has introduced any other control theories that would replace CAIR, and so we're really left with what we have presently. Who else can do it any better than what we've done?

Q. Sir, what is your understanding, if you have one, of the impact of the CAIR vacation on the TVA plants reflected in your model?

A. I have not done the explicit calculations to answer that question. I have an opinion, but I've not done calculations to answer it.

Q. Thank you, sir.

Dr. Tesche, I believe that you alluded to the fact that the VISTAS modeling were looking at two future years, I believe 2009 and 2018?

A. VISTAS began by looking at 2018 as the future year.

Q. And why that year, if you know?

A. Well, because 2018 figures very prominently in the Regional Haze Rule as the first interim checkpoint for demonstrating reasonable further progress towards 2060 final goal in regional haze.

Q. And why 2007? Or how did 2009 come into the mix?

A. It came in because the participating states in VISTAS and states around the country, many of them were charged with coming up with 8-hour ozone SIPS and fine particulate SIPS by the end of year 2007, and they were relying very heavily on the VISTAS data sets in the southeast states to provide the foundation for conducting the states specific modeling. And as time grew short, there was a recognition that it would be really helpful if the states had available to them newer or a

more recent future year, and 2009 was suggested as an appropriate interim year to use for assisting the states in their SIPS, which many of them do in 2007.

So VISTAS, in conjunction with a new organization called ASIP, involving many of the same states and players, combined efforts to generate a new 2009 emission inventory following the same rigorous principles that were used to develop the 2018 inventory.

Q. You mentioned ASIP.

A. Yes.

Q. If you could translate that acronym, if you could.

A. I don't remember those, the details. It's in our report, but I don't remember. Sorry.

Q. That's all right.

You said it basically involved the same VISTAS states?

A. Yes.

Q. Including North Carolina?

A. Yes.

Q. And North Carolina was involved with the ASIP effort?

A. Yes.

Q. And how did the TVA/Alpine team use the 2009 and 2018 future year inventories from VISTAS?

A. For VISTAS?

Q. For the modeling in this case.

A. Oh, okay. We recognized that the 2009 and the 2018

VISTAS ASIP inventories were by far the most current and peer-reviewed inventories available. And so we used them essentially as book ends to interpolate for all source categories -- except power plants in North Carolina and Tennessee -- to interpolate the emissions to the interim year 2013. Such interpolation is a common practice in emission modeling of future years when you must develop inventories for some interim time frame and you don't have the time necessarily to do the full-bore inventory development.

But the two book ends that we were interpolating between were as rigorous and as solid as we could find that were suitable for this purpose.

Q. To come up with the 2013?

A. Correct.

Q. Dr. Tesche, you've mentioned several times that the TVA/Alpine team did modify the VISTAS inventory information on both North Carolina power plants and the TVA fossil fleet.

A. Yes.

Q. Is that correct?

A. Yes.

Q. And could you explain to us exactly what you and your modeling team did in terms of modifying the VISTAS inventory?

A. Well, again, the focus of our modeling was to look at two scenarios. The 2013 scenario, with both TVA and North Carolina fleets, EGU fleets running at the Clean Smokestacks

level. Second was North Carolina Clean Smokestacks and TVA at their air quality compliance plan. So the only thing we modified in the inventories that we had produced by interpolation were the power plant emissions hour by hour for the North Carolina and Tennessee Valley fossil plants, the eleven fossil plants. And we did that manually by taking numbers out of reports and inserting them in the electronic files for the emissions model, and then using those files to support the air quality modeling.

Q. You referenced that you took them out of reports. Could you please describe to the Court what reports you're referring to?

A. Yes. The emission estimates for TVA and for North Carolina power plants, assuming the Clean Smokestacks level of controls, were taken directly out of the expert report written by Mr. Chinkin and Mr. Wheeler.

Q. What about the source of information for the, what I'll call the TVA plan scenario?

A. For the TVA plan scenario, we remained faithful to the EPA guidance that a future year inventory be based on best projections of the emissions of those sources in the future year. Our future year was 2013.

Because the emission rates that Sonoma Tech and Dr. Staudt had offered up did not reflect reasonable emission rates in the year 2013, we used the rates that were estimated

by Mr. Scott as best estimates for the effects of the controls that are poised to begin operation and are expected to be in operation in 2013, and it is those numbers that we used for the TVA fleet in the future plan.

Q. Mr. Tesche, we touched on both the CMAQ and CAMX modeling systems already in your testimony, but I'm wondering if you could spend just a few moments describing for us -- describing CMAQ for us. What sort of model is it we're talking about here?

A. Well, CMAQ is a sophisticated state-of-the-science computer modeling system. I emphasize the word "system" because it's got a lot of individual modules that it needs. But it's a modeling system that will simulate the chemical interaction of a wide range of pollutants emitted into the atmosphere from virtually any source you can think of. It treats the chemistry and the physics of the fate of those materials, including deposition, over the scale of the maps that we operate, which we saw earlier, for time periods, averaging time periods that are as short as five to ten minutes to as long as a year or more.

CMAQ algorithms are subject to peer review and continuous update from scientists around the world. CMAQ enjoys a conference every year in which new updates are presented and scientists give reports on what they've done with the model and what they've found and recommendations for

improvement.

Q. And I think you referred to the fact that the Environmental Protection Agency has used CMAQ extensively?

A. Well, they were the developer, so they have used it in many of their applications.

They began using it, to my knowledge, in the early '90s, and it was used for -- certainly for the CAIR rule, the Clean Air Mercury Rule. It was used in EPA's visibility modeling for 2001, that base year.

So EPA has used it extensively, both as an applications tool and as a research tool. There is a very aggressive research application of CMAQ, combining it with global climate models, to look at even bigger scale impacts.

Q. Has CMAQ also been used by state regulatory bodies.

A. Yes.

Q. Including North Carolina?

A. Including North Carolina.

Q. How intensive a user of computer power is that program?

A. It's not as daunting as many people think. Indeed, it is a complex and a sophisticated model, but, you know, a person with reasonable skills can build their own LINUX computer and download the code freely from EPA, the supporting software and databases, get tutorials on line, and actually make CMAQ model runs in their basement if they want to.

Certainly, that's not the scale of the VISTAS modeling, by any means. We used arrays of 40 or 50 computers because we were processing many jobs in parallel. But it's a -- it's a -- it's not a terribly challenging computer program to run for a person with skill in running complex models.

Q. You've also touched on the modeling system CAMX. And again, sir, if you could favor us with an overview of what is CAMX, what sort of model CAMX is.

A. CAMX is quite similar to CMAQ, and as a result of that similarity, CAMX and CMAQ produce results for ozone and visibility and fine particulate that are, in my opinion, largely equivalent.

But CAMX is more user friendly, written by consultants who really were in the heat of it, trying to apply these models in fast-paced studies. So it has many more accessory tools that help you probe air quality questions a little bit more than CMAQ. It does a few more things that CMAQ isn't presently coded to do. But I certainly wouldn't declare CAMX to be a better model. In fact, our practice is to use both in a corroborative sense, and it's been a very useful strategy.

Q. Has CAMX been accepted by the regulatory community?

A. Yes.

Q. Including the Environmental Protection Agency?

A. Yes. Their guidance manual clearly identifies CAMX and

CMAQ as acceptable models to use. They put the burden on the states to justify whichever model they pick.

Q. Has the EPA itself used CAMX modeling?

A. Absolutely. EPA used CAMX in the development of the -- or support for the NOx SIP Call; they used it in the CAIR modeling; they used it in the Clean Air Visibility modeling, in part, because of the nice attributes of these diagnostic tools I just mentioned.

Q. Before we turn to some of those diagnostic tools, what sort of computing power are we talking about in CAMX?

A. It's equivalent to VISTAS.

Q. To VISTAS?

A. Excuse me. It's equivalent to CMAQ.

Q. We're awash in a soup of acronyms, Dr. Tesche, and I understand it could be a little easy to get your tongue tied with them.

A. The issue is not computer power. The issue is storage of the massive amounts of input and output data. That's the bottleneck nowadays. So it's not computers; it's storage of the information. And that's why it's so important to be able to display the information in a way that portrays the results in meaningful and helpful manners.

Q. Would you mind expanding on that, Dr. Tesche? What do you mean by that, sir?

A. By the displays or the storage?

Q. About first the storage and then the displays.

A. Okay. Output of the CMAQ or CAMX models can consist of many terabytes of data. We're looking at concentrations of 20 chemicals every ten minutes for every grid cell at the ground and aloft for the space of a whole year, and that amount of information can accumulate and become very large. Together with the data that go into the model, those two massive amounts of data have to be stored someplace where the model can get to the input data quickly and spit out the output data quickly.

The model is faced with the challenge of taking the large output files and distilling that to information that is relevant to decision makers. So EPA and various organizations have been active over the years in developing software that will plot out the results, the main results of the modeling, to statistical summaries so that we can better understand, you know, the differences between things. And that's a very active part of the modeling process.

Q. What about the display of the data by overview?

A. That's part of the post-processing and part of the challenge, to find ways to display a year's worth of data of concentration sufficient that varies every hour and every grid cell, at the ground and aloft, and display it in a manner that's intelligible when you look at one's screen here.

Q. And intelligible to policy makers.

A. To everyone that would look at it, but especially policy makers, because they're the ones that need to use the information to make their decisions.

Q. Sir, I'd like to turn back to something you remarked on. I think you called them the diagnostic tools that are available with CAMX.

A. Yes.

Q. What were you referring to?

A. CAMX has a suite of diagnostic or probing tools, if you will, that are designed specifically to squeeze out a little more information out of the model simulation than we would normally get out of our standard post-processing programs.

Q. Did you use some of those CAMX probing tools in the modeling that you and your team performed for this case?

A. Yeah, we sure did.

Q. And could you describe those -- the probing tools that you've used?

A. Okay. One probing tool is OSAT, Ozone Source Apportionment Technology, and that probing tool, similar to the one I'm going to describe in a moment, is designed to provide more information about the impacts of individual sources of air pollution, whether it be from a refinery or a tree or a power plant or whatever, on a downwind ozone air quality.

So if you have a dozen monitors in your urban area and you want to understand which source of wind is causing my air pollution -- is it NOx from a Tennessee power plant? Is it a hydrocarbon from some lagoon out in the boondocks? What is causing it?

OSAT, as a computational algorithm, sort of is a hitchhiker on the main CAMX model simulation. It kind of goes along with that hour-by-hour, minute-by-minute air quality simulation and extracts relevant information from the chemical processing and the transfer processing and spits it out to a separate file that the user can then aggregate and develop estimates of source receptor impacts.

For example, you know, what is the impact in the -- at the Aldean air quality monitor in Houston as the result of, say, seven upwind individual refineries. OSAT will allow us to rank order the contribution of those seven refineries to the ozone implement being predicted at the Aldean monitor.

So, in that sense, it's a very helpful tool that can be used to guide emission control strategy development. For example, if we know that at that monitor we need to control emissions, it would tell us that it might be better to control emissions from this area with this set of refineries over here as opposed to over there, because under the conditions of the meteorology simulator, the OSAT tells us that source sector area has a greater effect on ozone than

this area.

So in the case that we're dealing with, we operated the OSAT model for the year 2002 conditions for the entire summer of the ozone season, and we followed with OSAT the emissions from the TVA and the North Carolina power plants and were able to identify the contribution of each facility to ozone downwind.

Now, that did not perturb the CAMX calculation. It doesn't affect the output of the air quality model, but it supplies that additional diagnostic information that can be very helpful at times. Similarly, there's a PSAT source apportionment tool that does essentially the same thing for particulate matter. We use that as well.

Q. And the description for PSAT would be the similar as the description for OSAT?

A. Correct.

Q. It's another hitchhiker on the basic CAMX frame?

A. That's right. Those two capabilities are largely the reason EPA used CAMX in the CAIR and the CAMR visibility rules, because they wanted to be able to look at individual source regions. In this case, it was states. But we used it in this case because we felt it was very important to have the ability to differentiate between individual generation stations.

Q. Now, Dr. Tesche, your expert disclosure reports

indicate -- and I think this has already been clear in your prior testimony -- that you and your team here used both CMAQ and CAMX.

A. Correct.

Q. Why did you do so?

A. Our experience in VISTAS and in other studies was that the joint use of these air quality models could be a very powerful capability to add value to the modeling.

Because I just mentioned that if we had run -- if we had run just CMAQ, we would not have had the ability to run the PSAT and OSAT calculations and learn the information we did with CAMX.

We had an experience in VISTAS where we ran both CAMX and CMAQ and discovered that when we did our very detailed model evaluation, we found inconsistencies in the model's predictions of aerosol associated with secondary organics, and we scratched our head and couldn't understand why it was. That generated an intensive research activity to look into why the two models, given the same inputs, were producing different outputs.

What we found was that there is a shortcoming in the chemistry of the CMAQ model for secondary organic aerosol. And that I wouldn't say delayed the VISTAS program, because there was plenty for us to do, but it prompted a search and applications effort to put in a new chemistry, or a

supplement to the chemistry at CMAQ, that would account for emissions from the natural vegetation, the terpenes, sesterpenes emissions, the kinds of emissions that some associate with the blue haze in the Smoky Mountains. Those were put more explicitly into the mechanism of both models and represented a science contribution.

So in using the two models in a corroborative sense, we were able to find out or be alert to differences that were, in this case, important that were resolved.

In the present application we used two models because we wanted to have the support of different diagnostic tools to help answer the range of questions we were addressing and to provide corroboration that the impacts on air quality we were getting with one model were generally consistent with what the other model was showing.

Simple reliance on one air quality model means that the decision maker has to assume that that's the right answer. And this modeling is too complex to suggest that any one model that you chose is the final answer.

Q. Did the modeling results you obtained for this case from CMAQ and CAMX, were they compatible with each other?

A. They were, yes. The predictions of future year and the predictions in base cases were reevaluated, and both models in the base case, shows that they were operating what I call a functionally equivalent mode. That is, there were

certainly differences, and probably differences with every pollutant simulated, but they were not large or significant differences. Within the different formulations of the model, the output, in our judgment, was quite consistent.

Q. The next area I'd like to turn your attention to, Dr. Tesche, is the question of modeling uncertainty.

Could you please describe for the Court the sources of uncertainty in modeling results?

A. There are two basic categories of uncertainty that attend air quality model predictions. One is sort of an irreducible or an inherent uncertainty, and that derives from the fact that the atmosphere is fundamentally turbulent, random, chaotic, whatever word you want to use. But it does not lend itself to precise simulation. There is a randomness to the atmosphere and the chemistry in it that we simply cannot predict with precision and are unlikely ever to be able to do so in my -- in my opinion. We have to live with that.

So when we model a future year, there are going to be some uncertainties just because the atmosphere is randomly chaotic. We have to live with that. What we don't have to live with are the uncertainties in the modeling that come about because we have not done a good job in developing our models or we've not spent the money needed to build the databases that are needed to evaluate these models and to

correct their flaws where they're found, or where we have not worked hard enough to prepare the inputs to these models in a really thoughtful manner such that the model is given every opportunity to function properly with the inputs.

So that's a model formulation area of uncertainty, a model data input area of uncertainty, making sure you get the input data formatted and analyzed properly for the model.

And there's a third area of uncertainty that derives from the fact that these models are, at best, approximations of the atmosphere. They're grid models, and the spatial resolution of each grid box is no better than 12 kilometers on the side. You get one prediction for a pollutant every ten minutes in that grid box.

In contrast, when you have an ozone monitor or fine particulate monitor out in the field, it's sampling concentrations through a small tube, and so the volume of gas that is sucked in by the monitor is quite different than the air quality model is predicting over a spatial scale of 12 kilometers by 12 kilometers by, say, 150 meters high. So that incommensurate ability between the measurement and prediction leads to a fundamental uncertainty in the model, such that when we do model evaluation and we see a difference between prediction and observation, we don't know who is the bigger culprit. The modeler will say it's a measurement error; the experimentalist will say the model is involved.

The reality is it's somewhere in between.

But the fact is that the differences between the prediction and the observation give us a signal of the uncertainty in the modeling exercise. And one of the core unanswered questions in all air quality modeling is how can we extrapolate that knowledge of the uncertainty in the model prediction in the base case to a future year when we're comparing two strategies. And that is a grand challenge, and that problem has not been solved, and the best we can do is make our very best professional estimates as to what the uncertainty is that attends those differential calculations of future controls.

Q. Dr. Tesche, on the terms -- before we head to some other questions in this uncertainty area, what's the implications for uncertainty in trying to project into the future years for emission rates and emissions impacts?

A. Can you repeat the question, please?

Q. I'm sorry, sir. That was a little scrambled, and I apologize.

Dr. Tesche, what impact on uncertainty comes from trying to predict future years' behavior?

A. I think the challenge in estimating future year emission inventories that serve as a foundation for our air quality planning is huge. It's very large. It transcends the uncertainties we have in modeling the current year.

Who could have imagined air quality planning in Baton Rouge for 2007 after the hurricane went through and wiped out a large number of petroleum refineries, some power plants and a lot of the social infrastructure? For the ozone SIP in 2007 that we're currently working with, the Louisiana Department of Environmental Quality, we've got a real problem trying to come up with future emission inventories in light of that unpredictable natural event. Who is to say that there won't be some other event outside our grasp that isn't clear in our crystal ball?

So there is uncertainty in future year emission information, and the best we can do, as the EPA has guided us, is to use our very best judgment. And I submit that we really ought to be running alternative future year control scenarios that reflect the range of uncertainty that attends our future year emission estimates.

Q. Dr. Tesche, again, I believe you've reviewed the expert disclosure reports submitted by Mr. Wheeler and Chinkin and their staff from STI. Am I correct in that, sir?

A. Yes, sir.

Q. And I believe that Messrs. Wheeler and Chinkin discussed their assessment of uncertainty in their modeling results, comparing two future year proposed control cases.

Do you recall that, sir?

A. Yes.

Q. Could you give us your assessment of their views on that uncertainty issue?

A. I have read all of Mr. Wheeler's testimony in this proceeding and a portion of Mr. Chinkin's testimony, and of those portions I have read, I read their testimony on the precision of the CMAQ model when it's used to look at the differences between two power plant control runs, and they attribute a level of reliability or precision to those differential estimates that in my view are simply astonishing.

I have never heard any other individual in the modeling or science community assert that these models, when applied in the fashion that Chinkin and Wheeler applied, could produce anything anywhere near that level of precision. A simple thought experiment would help one see how ridiculous that assignment of precision is.

They assert that the precision of a fine particulate concentration deriving from the difference between two power plant models is as fine as .01 micrograms. .01. Now, EPA, in its CAIR study, says that the significance of PM is .1 -- or excuse me -- .2. Set that aside for the moment.

If their level of precision is correct, that means that, if we simulated the entire TVA fleet, that we can model the impact of the fleet to within 100th of a microgram per cubic meter. Now, imagine, we add in the North Carolina fleet, and

the cars, and the factories and the refineries and area sources. Each time we do that in a differential manner, they're asserting that the precision of this model, in simulating an individual source category, is essentially 100th of a microgram. If you add up all the sources in the region, the composite air pollution all together, do you still have a precision between two scenarios of .01?

The answer is no. Obviously, when we evaluate these models, whether it be CMAX or CMAQ, and look at the PM2.5 prediction against the measurement, we find that there are errors on the order of 40 to 60 percent. Sometimes less. Maybe 20 percent or 25 percent. And that's a robust number across hundreds of monitoring stations around the U.S., and for several years.

So to assert that these models possess a degree of precision down to two decimal places is just simply astounding. I have never heard anyone in the science or modeling or regulatory communities profess that level of faith, as he calls it, in the ability of these models to simulate changes between individual control scenarios.

Q. Dr. Tesche, before we get into some of the details of the information that you and your team have generated in the modeling effort you've conducted here, there is one other preliminary matter I'd like to cover with you, if you would please bear with me.

I think, Dr. Tesche, you mentioned that the information was outputted to these modeling runs and into the, I think you called it the terabyte level?

A. Yes.

Q. Translating it, would it be accurate to say that we're talking about a torrent of data?

A. Well, it's -- if you're a laptop guy, yes, it's a torrent of data, but if you're a numerical modeler, it's a standard output, and you have large disk drives that you can buy for $300 on your desk, and you can get 20 of them. It's a manageable amount of data, but it's large, and it requires skill in managing that kind of information and backing it up and treating it properly.

Q. And the input information is voluminous?

A. Yes.

Q. Again, sir, I believe that in Mr. Chinkin and Mr. Wheeler's supplemental report, they identified some omissions in the TVA emissions that you modeled?

A. Yes. They found a mistake we made.

THE COURT: Let's take our midmorning break at this point and we'll get back to that. 15 minutes.

(Recess.)

[END OF VOLUME 9A-1]

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF NORTH CAROLINA
CERTIFICATE OF REPORTER

I certify that the foregoing transcript is a true and correct transcript from the record of proceedings in the above-entitled matter.

Dated this 25th day of July, 2008.

S/ Karen H. Miller

Karen H. Miller, RMR-CRR
Official Court Reporter